Informational Leaflet 41

FURTHER STUDIES OF THE AFOGNAK LAKE SYSTEM

By:

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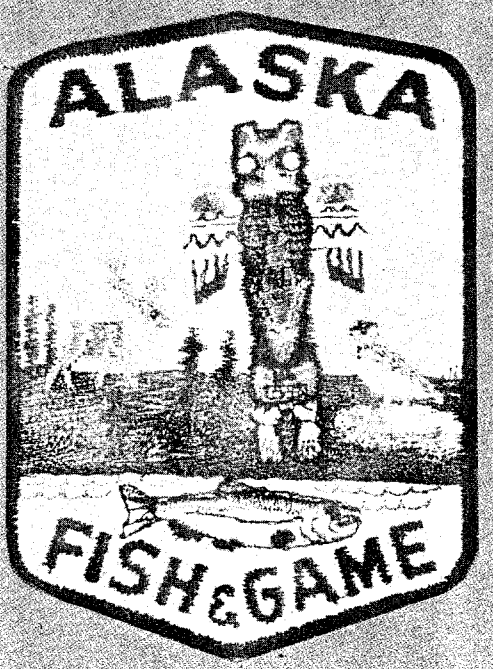

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FURTHER STUDIES OF THE AFOGNAK LAKE SYSTEM

INTRODUCTION

A preliminary survey of Afognak Lake (Figure 1) and its tributary system was made in 1961 by personnel of the Alaska Department of Fish and Game[1]. That report includes a description of the lake system and a discussion of the history of the salmon runs. The 1961 survey had as its objectives a rather detailed analysis of the spawning facilities in the tributary streams, abundance and distribution of spawning sockeye, and limnological studies of the lake.

The present study, conducted from May 2 to September 15, 1963, was chiefly concerned with the life histories of an interrelationships among the various species of fish in the system with a view toward determining biological factors limiting sockeye salmon production.

Charles Polityka, graduate student in Fisheries and Wildlife at Michigan State University, assisted the writer in the field program, and was responsible for the part of the study dealing with food interrelationships among the various fish species.

AFOGNAK RIVER STUDIES (EMIGRATION)

To facilitate sampling and enumeration of fish in the outlet stream, a weir was constructed one-half mile from the lake outlet. The weir, originally placed in the stream on May 10th, was built across the stream, 55 to 60 feet in width, with an adult gate and a smolt trap provided near the middle of the stream (Figure 2a). Small fish migrating downstream, when carried against the 1/4 inch mesh screen, were unable to swim away. The screens were therefore removed until wings were added to direct the emigrants to the smolt trap (Figure 2b).

Sockeye Smolts

Sockeye smolts were first taken at the weir on May 12. The major emigration did not begin until one week later and continued until late June, although the peak emigration occurred between May 27 and June 10; the modified weir became operational on the latter date.

We measured and took scales from samples of smolts at intervals between May 12 and June 18. Analysis of the length-frequency data, summarized and plotted by months in Figure 3, shows a smaller, narrower range in length among later emigrants. The reduction in range of length as emigration progresses may be the

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[1] Sheridan, William L., William R. Meehan, and L. Revet. 1961. Preliminary survey of Afognak Lake. Alaska Department of Fish and Game Informational Leaflet No. 5.

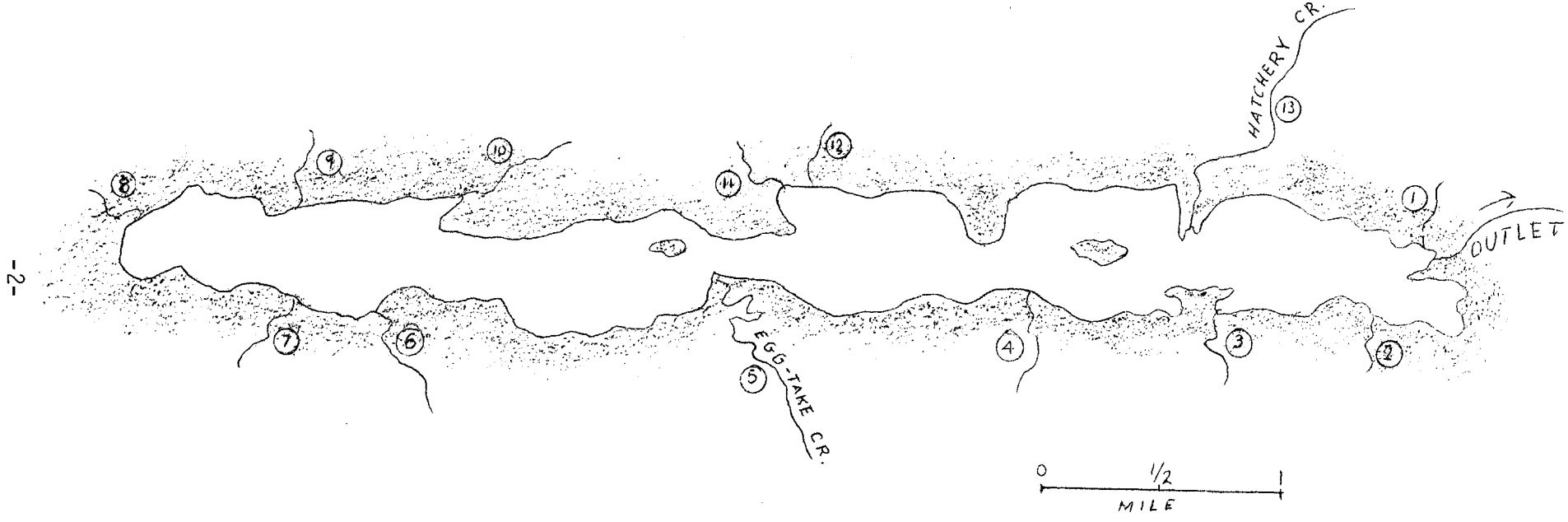
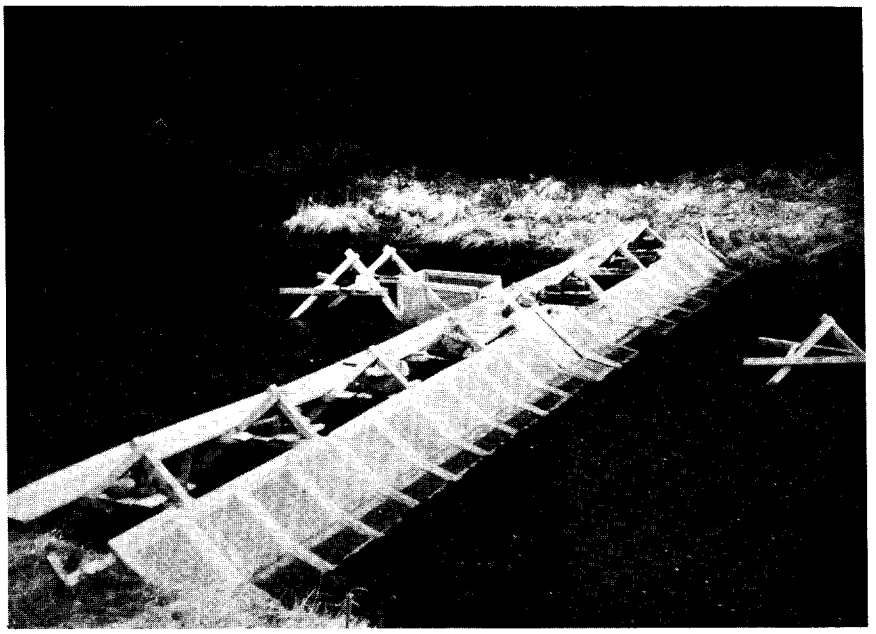


Figure 1. The Afognak Lake system showing tributary numbers corresponding to Table 3. Stippled area indicates observed beach spawning.



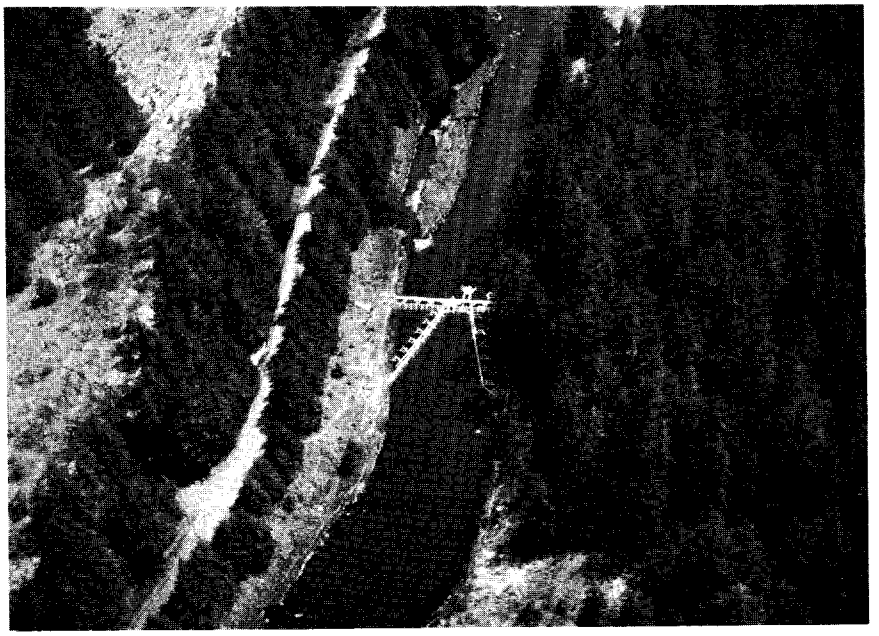


Figure 2. The Afognak River weir as originally constructed (a) and after modification (b).

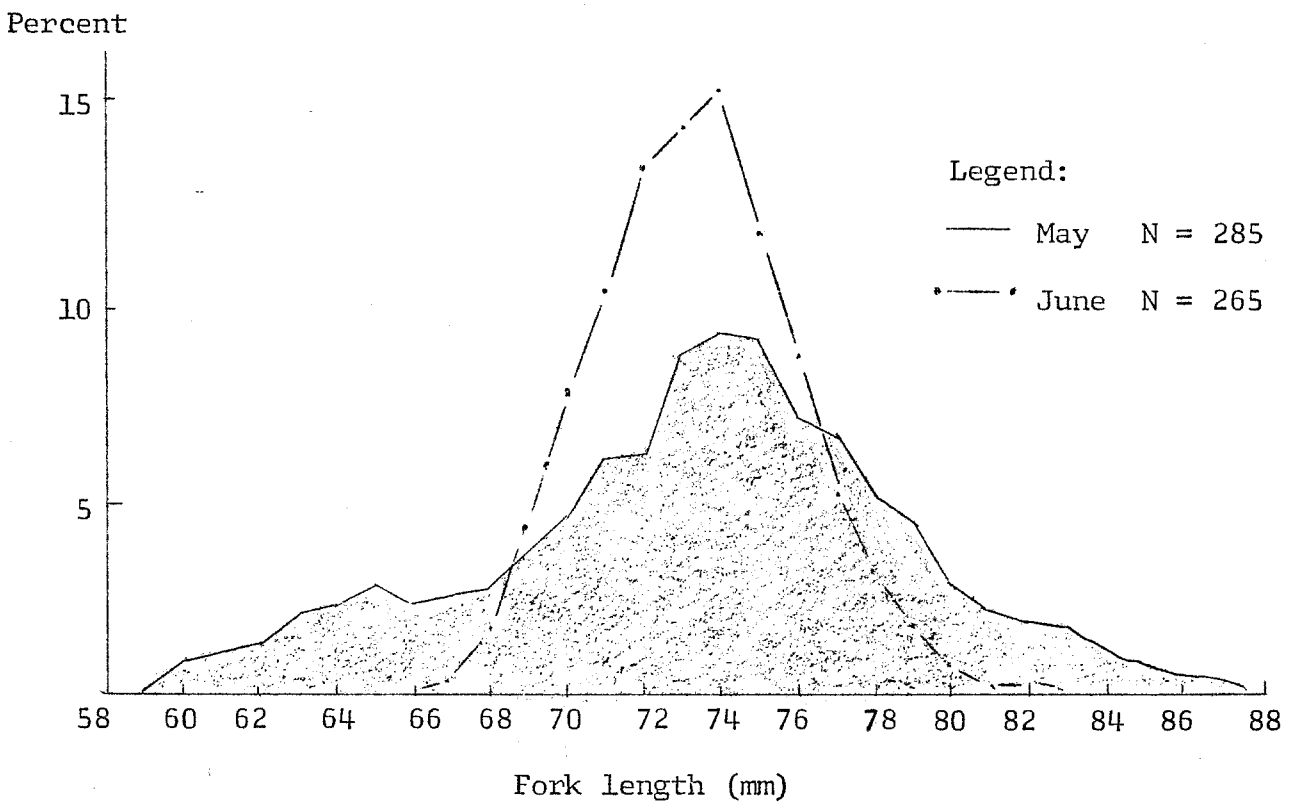


Figure 3. Length-frequency distribution of emigrant sockeye salmon smolts, Afognak River, May and June, 1963.

result of earlier movement of the larger and older smolts, and growth of the smaller fish during May. Evidence of the former may be found in the fact that our June scale samples contained no two-year-old smolts. We have no other evidence of growth of the smaller fish during May, but such growth does not seem unreasonable. There was no change in the average length of fish as the emigration progressed; the mean fork length was 73.4 millimeters in both May and June.

The age of a limited number of smolts was determined. Table 1 shows the age distribution of the samples with respect to length and time of capture. It is apparent that most of the smolts emigrate after spending but one winter in the lake, and that the two-year-olds tend to leave the lake earlier in the migration.

Samples of smolts were preserved for food-habit studies.

Coho Smolts

Coho smolts emigrated throughout the month of May; they ranged in size from 55 millimeters to in excess of 200 millimeters.

Pink Fry

The time and extent of pink fry emigration is not known. It is believed that most of the fry had left the stream before May 10th, although several thousand were observed at the weir from May 10 to May 20.

Cottus aleuticus

Sculpins were migrating downstream at the time of installation of the weir (May 10), and for twenty days thereafter. Most of the specimens examined were sexually mature and ready to spawn. Females outnumbered males by a ratio of 4:1. Figure 4 shows the length-frequency distribution of this species. There were no significant difference in the mean total length between the sexes.

Stomachs were removed from approximately 100 specimens for food study. Insects accounted for over 75% of the diet; a few pink salmon fry were taken, but since the sculpins were collected at the weir where pink fry were trapped, the extent of their inclusion in the normal diet may be less than indicated by this study.

Dolly Varden Trout

Emigrating adult Dolly Vardens were found in Afognak River upon arrival (May 2nd). No estimate of the emigrating population is possible. However, nearly all emigrants had moved out of the river prior to the major emigration of sockeye smolts. Cursory examination of numerous stomach samples of Dolly Varden disclosed no predation on sockeye smolt in the river; even if there were predation the earlier emigration of the Dolly Varden would preclude serious damage to the sockeye smolt population.

Table 1. Age distribution of sockeye salmon smolts with respect to length and month of capture, Afognak River, 1963.

Fork length (mm)	May		June	
	Age I	Age II	Age I	Age II
66	1	-	-	-
67	-	-	-	-
68	1	-	1	-
69	1	-	-	-
70	1	-	2-	-
71	3	-	4	-
72	1	-	3	-
73	1	-	10	-
74	4	-	5	-
75	3	1	8	-
76	2	-	1	-
77	2	-	1	-
78	3	-	-	-
79	1	1	1	-
80	1	-	-	-
81	2	-	-	-
82	1	-	-	-
83	1	-	-	-
84	-	-	-	-
85	1	-	-	-
86	-	1	-	-
87	1	2	-	-
TOTAL	31	5	36	0

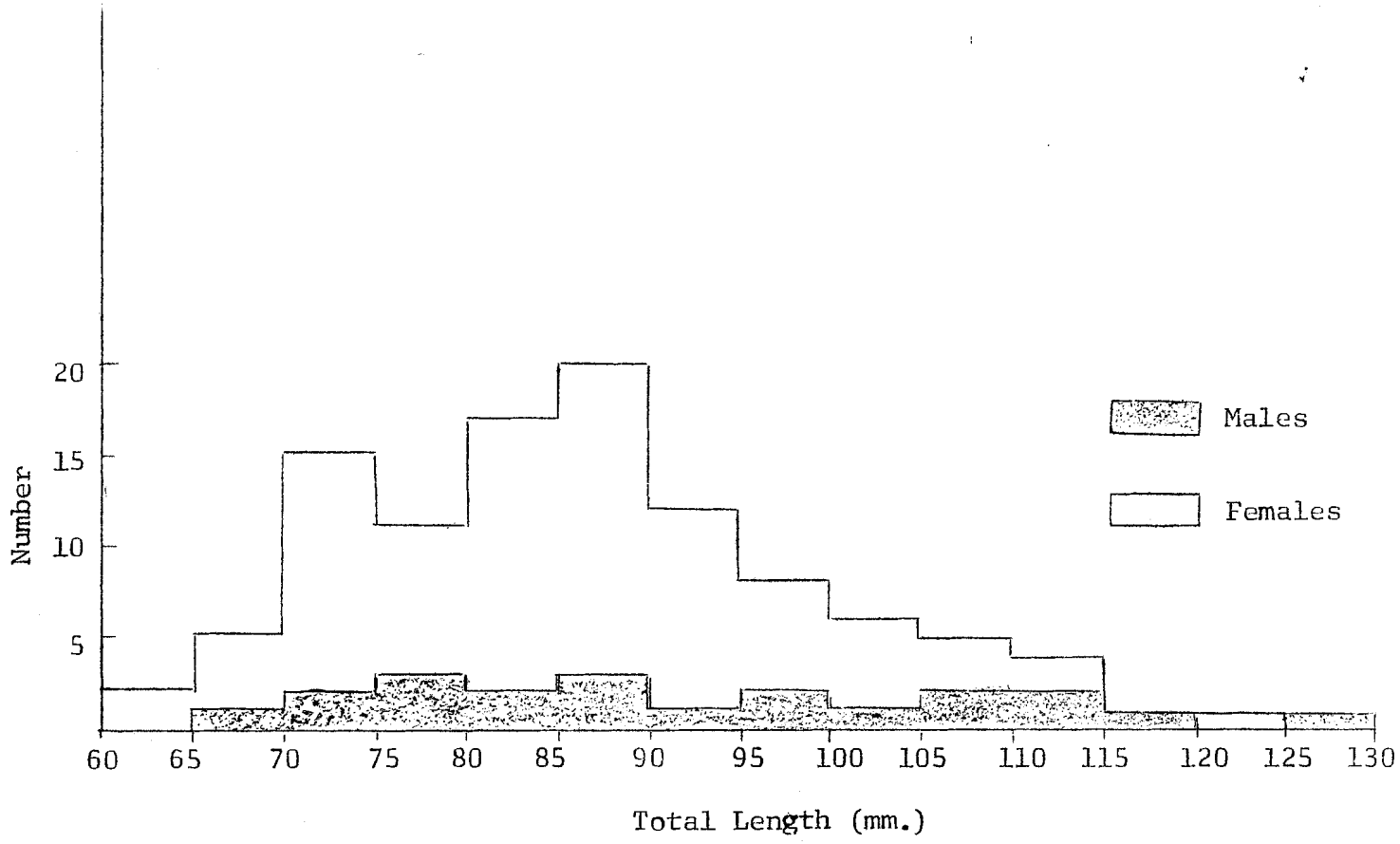


Figure 4. Length-frequency distribution of sculpins taken in Afognak River, May, 1963.

Summary of Emigration Studies

The Dolly Varden, coho fry and smolt, pink fry, and sculpin emigrations apparently start before May 1. All of these species have completed their emigration prior to the peak emigration of the sockeye smolts which occurs during late May and the first two weeks in June. There is no evidence, therefore, that the sockeye salmon smolt population suffers from either competition for food or predation during their emigration from Afognak Lake to salt water.

AFOGNAK RIVER STUDIES (IMMIGRATION)

Another phase of the project dealt with the immigration of fish from salt water into the lake. Most of our efforts were devoted to the sockeye salmon, their numbers, size and age distribution, adult to jack ratio, fecundity, and distribution in spawning streams with respect to time of immigration.

Sockeye Salmon

The first adult sockeyes were observed in the river, two and one-half miles below the lake outlet on May 25th. Four days later, three salmon were captured in a gill net in Afognak Lake, three miles from the outlet. On June 4th adult sockeyes were taken at the extreme upper end of the lake, indicating that within a 10-day period substantial numbers of salmon had entered the lake. Immigration continued throughout the months of June, July, and August with an estimated 80% of the salmon entering the lake before mid-July.

The size distribution of the immigrating sockeye salmon is shown in Figure 5 (samples taken periodically from 6/4 to 8/7). The bimodal curves representing both sexes suggest two age groups of each sex. Table 2, the size distribution of the various age groups, shows that the model size of each age group coincides with the modes in the size-distribution curves. The overlapping in size between ages in both sexes, however, precludes the use of size as an indication of age within the range of overlap.

An examination of the data in Table 2 verifies the earlier conclusion (from the smolt study) that a very high percentage of the sockeye smolts remain in fresh water only one year. There appears to be no advantage in growth accruing to those smolts spending an additional year in fresh water. While we have only three fish in our sample in this category, each fish was at or below the average size of fish one year younger but having spent the same number of years in salt water.

Sheridan et al. (op. cit.) reported an adult to jack ratio of 7:1 in 1961. The spawning population in 1963 contained a much larger proportion of jacks. Weir counts made one day each week during June indicated a 1:1 ratio. Total weir counts from July 10 through August were 1,902 adults and 1,655 jacks. Two spawning stream counts in which jacks and adults were distinguished were made in Hatchery Creek on July 27, when there were 108 jacks and 58 adults; and on August 2, when there were 326 jacks and 146 adults. Caught in gill nets in the lake from May 29 to July 26 were 62 jacks and 56 adults. It is therefore believed that the entire run of sockeye salmon in the Afognak Lake system con-

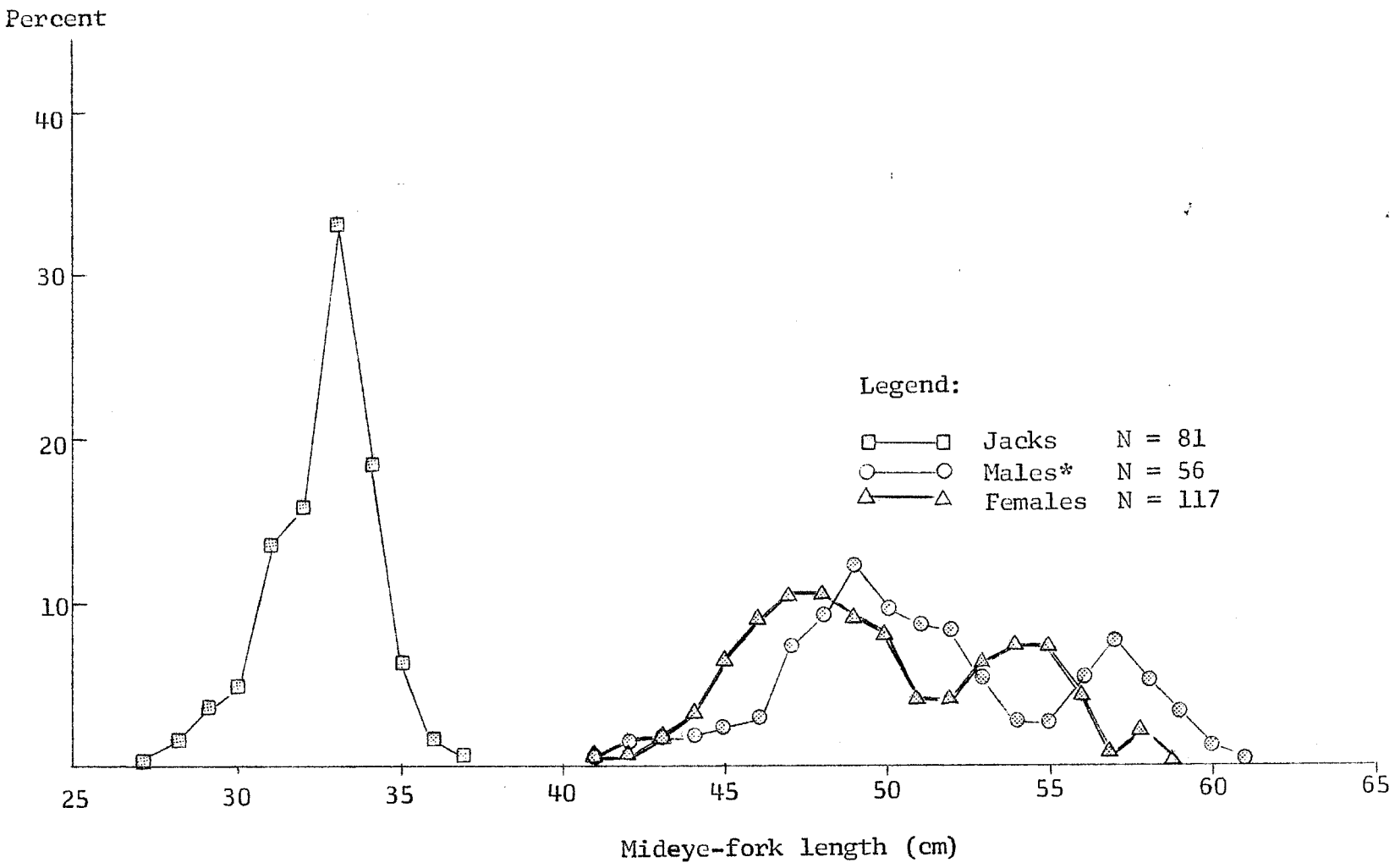


Figure 5. Length-frequency distribution of immigrant sockeye salmon, Afognak River, 1963.

* Excluding jacks

Table 2. Length-frequency distribution by age and sex, of sockeye salmon in Afognak River, 1963.

Mideye-fork length (cm)	Age-Females			Age-Males, excluding jacks			
	4_2*	5_2	5_3	4_2	5_2	5_3	6_3
42	1	-	-	2	-	-	-
43	2	-	-	-	-	-	-
44	4	-	-	-	-	-	-
45	7	-	-	2	-	-	-
46	11	-	1	2	-	-	-
47	13	-	-	1	-	-	-
48	15	-	-	7	-	1	-
49	10	2	-	7	-	-	-
50	7	3	-	8	-	-	-
51	2	2	-	3	-	-	-
52	-	3	-	4	-	-	-
53	-	8	-	2	1	-	-
54	1	9	-	-	1	-	-
55	2	8	-	-	1	-	-
56	-	6	-	-	3	-	-
57	-	1	-	-	5	-	1
58	-	2	-	-	3	-	-
59	-	-	-	-	-	-	-
60	-	-	-	-	2	-	-
TOTALS	75	44	1	38	16	1	1

*4_2 The first number of the pair indicates the total age of the fish, beginning at the time of spawning. The second number, written as a subscript, indicates the year of life in which the fish migrated to sea, again beginning with spawning.

tained approximately a 50:50 ratio of jacks to adults, with perhaps more jacks than adults. The reason or reasons for the rather abrupt increase in the proportion of jacks in this system are not obvious. Comparisons with other lake and river systems should disclose whether this situation is widespread or unique to Afognak Lake.

Lengths and weights of immigrating adult sockeye salmon are shown in Figure 6. The mathematical regression expressing the length-weight relationship has not been determined, but it appears that a linear relationship may serve as well as an exponential one.

Fecundity studies consisted of counting the eggs from 24 females; the results are shown in Figure 7. These fish contained from 800 to 1,000 fewer eggs than fish of the same size from Brooks Lake, reported by Hartman et al.[1] This difference would be important when determining potential egg deposition on the basis of number of spawning females. For the Afognak Lake system, due to the smaller average size of fish (50 centimeters) and lower fecundity, a figure of 2,500 eggs per female would be more realistic than 4,000 as used at Brooks Lake.

In an effort to determine the distribution of adults throughout the lake, and particularly in the two major spawning streams, fish were tagged at the weir at approximately weekly intervals, beginning on June 11 and continuing for eight weeks. To enable recognition of fish tagged at different times, colored plastic strips approximately 1/2 x 3 inches were fastened beneath the right disc of the Peterson tag. The tagging data are as follows:

Date(s)	Color	Number tagged
June 11	Peterson tag only	13
June 18-19	Yellow streamer	25
June 26	Orange streamer	27
July 4	Red streamer	35
July 10	Green streamer	30
July 24	White streamer	21
July 30	Orange and white streamer	27
August 7	Green and white streamer	8
	TOTAL	186

[1] Hartman, Wilbur L., W.R. Heard, C.W. Strickland, and R. Dewey. 1963. Red salmon studies at Brooks Lake Biological Field Station, 1962. U.S.F.W.S. Bur. of Comm. Fish. Manuscript Rept. MR 63-6:36 pp.

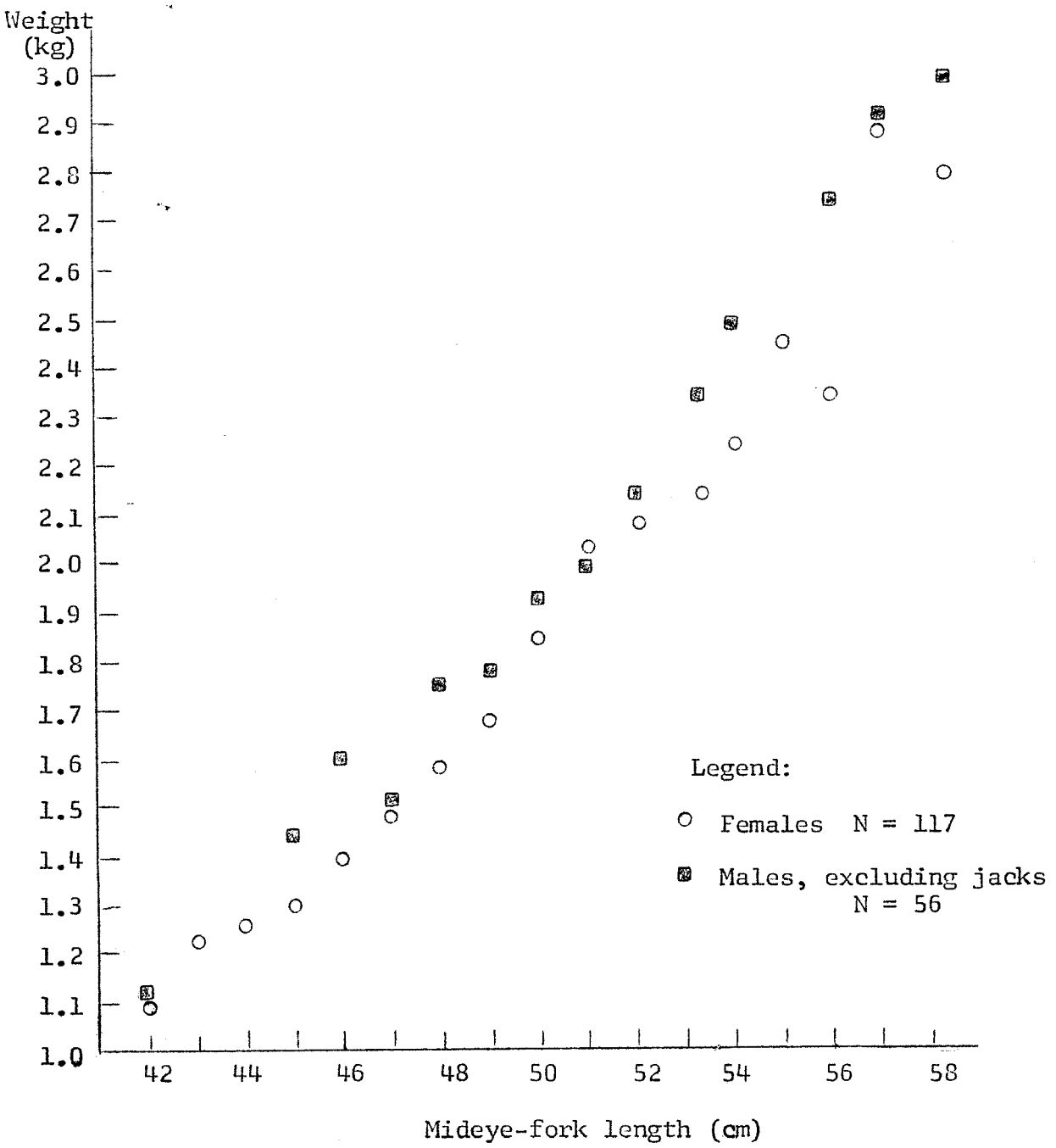


Figure 6. Length-weight relationship, by sex, of sockeye salmon, Afognak River, 1963. Weight shown is average weight of all fish in given length interval (42 cm = 420-429 mm, etc.).

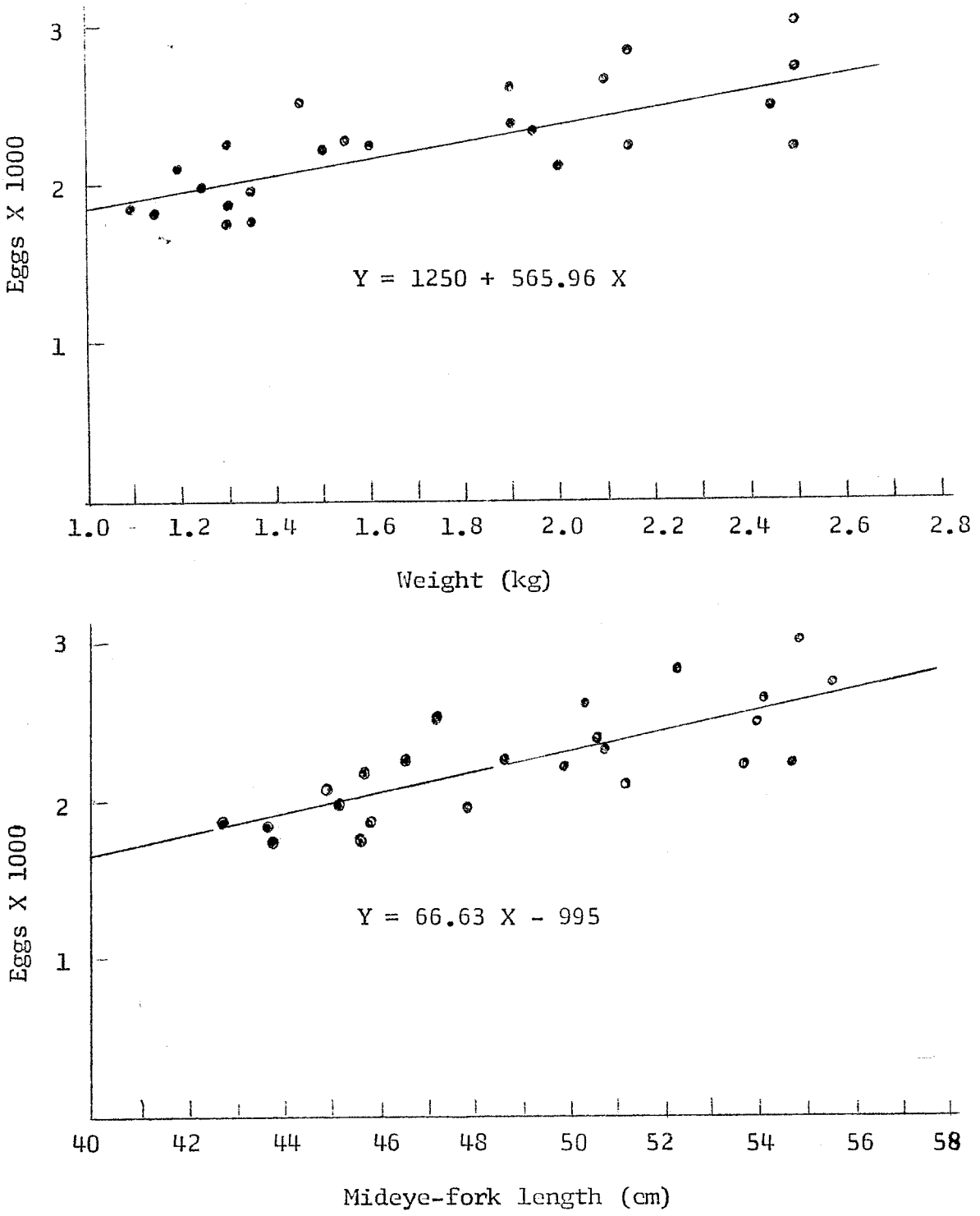


Figure 7. Number of eggs in relation to weight (above) and length (below) of sockeye salmon, Afognak River, 1963.

The combination colors of the last two dates consisted of a 3-inch background color with a 1-1/2 inch white streamer covering half of the colored streamer.

Dolly Varden

The first immigrants were observed in the river about two miles from the lake on June 24. Starting on June 29 the weir was attended by Kitoi Bay Research Station personnel, whose primary purpose was to study the Dolly Varden immigration. The peak movement occurred between July 9 and July 21, during which time approximately 20,000 of the total run of 30,000 fish passed through the weir. Further details of the Dolly Varden immigration will undoubtedly be the subject of a report from Kitoi Bay Research Station. Stomach examination of immigrating Dolly Varden indicated that these fish did not feed in the river.

Other Species

Sculpins *(Cottus aleuticus)* appeared at the weir on July 8, and with a few days reached what is presumed to be their normal population density throughout the stream. No collection of these fish were made.

Also passing through the weir during late August and early September were 2,961 coho and 478 pink salmon. Most spawning of these species takes place below the weir site so the numbers passing through the weir are not indicative of population size.

LAKE STUDIES

In their preliminary study of Afognak Lake, Sheridan et al. (op. cit.) found no evidence of thermal stratification in late July, 1961, and suggested that studies be made earlier in the summer to determine whether the lake is truly non-stratifying. Figure 8 shows the temperature profiles for three dates in the summer of 1963 and Figure 9 shows the lake location. It is evident that thermal stratification occurs, but only for a relatively short time. The date of the third series, August 2, apparently marks the approximate beginning of the fall overturn inasmuch as the shallower water at Station 1 is nearly homothermous while the deeper waters of Station 2 remain several degrees colder than water at mid-depth.

The fish population of the lake was studied throughout the summer by means of monthly gill net sets at seven stations (Figure 9). Only a limited amount of seining was done in the protected coves where the smaller fish tended to congregate.

The following species are present in the lake: Dolly Varden and rainbow trout, coho and red salmon, and sticklebacks. Stomach samples were taken from all species except red salmon in an effort to determine food interrelationships. These studies, together with a systematic study of lake-bottom food organisms, will form the subject of Mr. Polityka's thesis and will be reported in detail separately. Preliminary study shows little evidence of predation upon red salmon fry or smolts by other fish species.

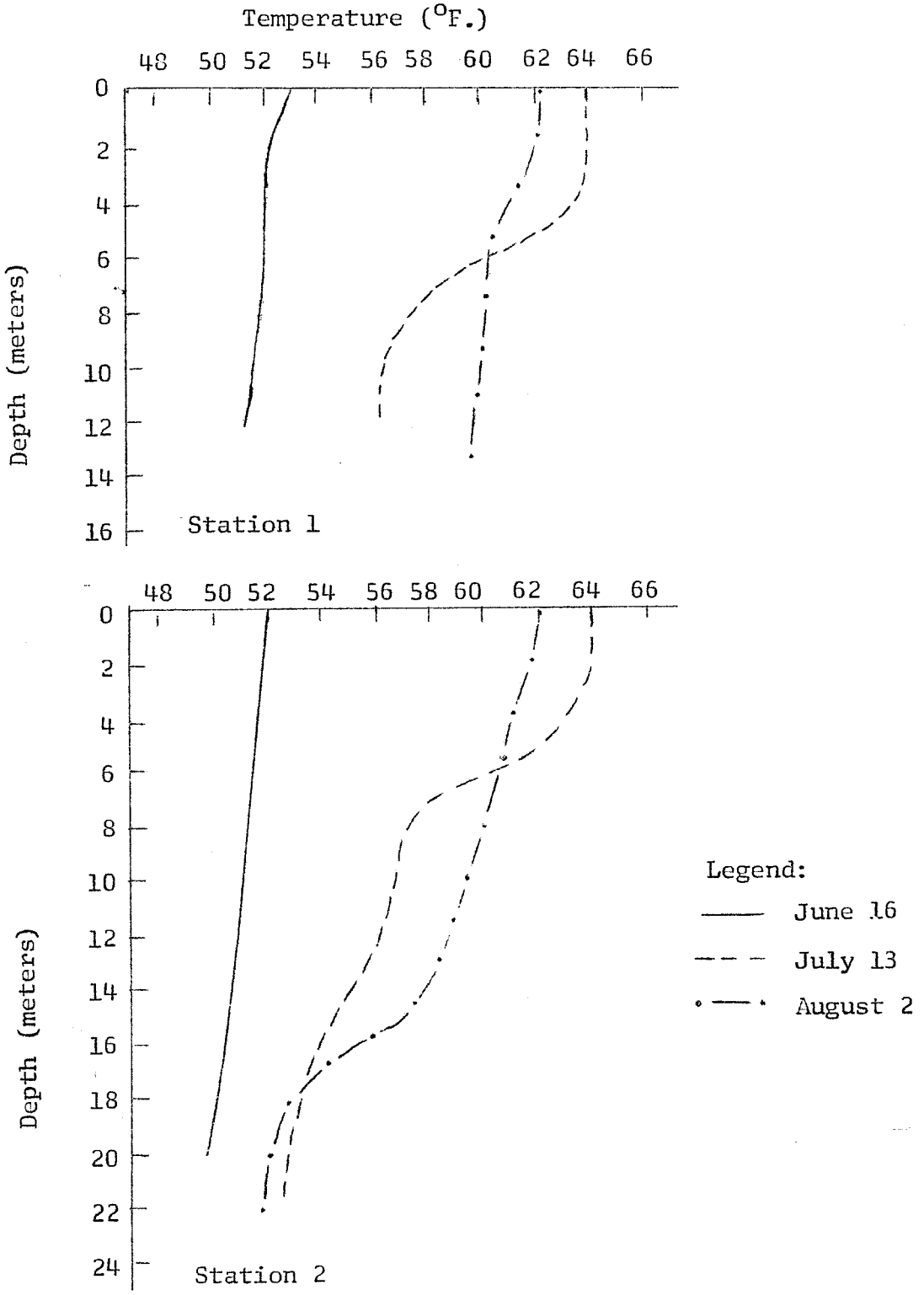


Figure 8. Temperature profiles in Afognak Lake, 1963.

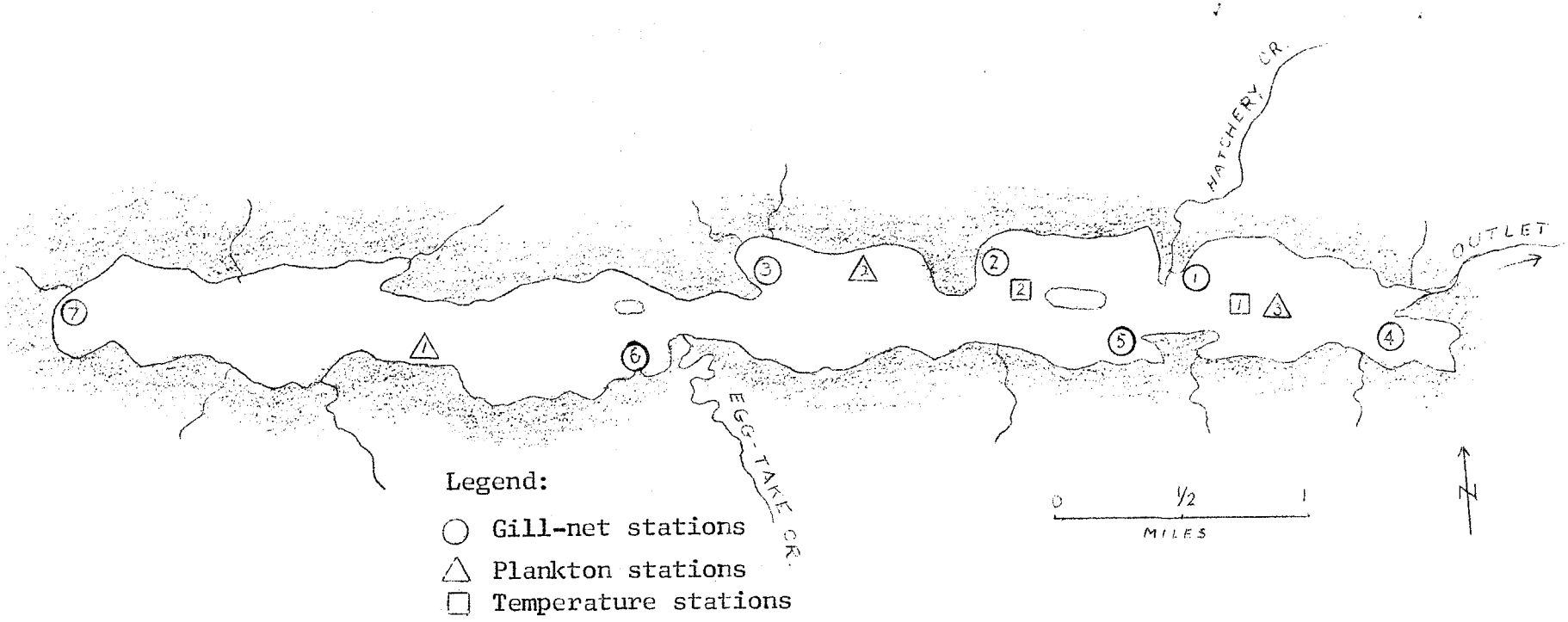


Figure 9. The Afognak Lake system.

Dolly Varden

This species is the only fish in the lake which is abundant and of sufficient size to constitute a threat to young salmon from the standpoint of significant predation. But as stated above, evidence of predation during the months of May, June, and July is lacking. (Netting from late July through August was discontinued because of the abundance of adult salmon in the lake.) Studies made during the fall, winter, and early spring are needed to establish the extent of Dolly Varden predation. Of particular importance may be the period when the salmon fry emerge from the gravel and migrate into the lake.

Table 3 gives data on length and weight of emigrant, immigrant, and resident Dolly Varden, sexes combined. The emigrants were taken from the river, immediately below the lake outlet; the residents are represented by the June lake population plus some fish captured in July which could be distinguished from the sea-run fish by their coloration. The increased weight of the fish upon return from salt water is apparent, but the returning fish weigh slightly less than resident fish of equivalent lengths.

Other Species

Coho fry and fingerlings and sticklebacks were found in the protected bays and coves in shallow water. Seining provided samples of these species.

Young-of-the-year coho salmon measured from 25 to 36 millimeters. Lengths of older fish (probably age I) were uniformly distributed between 42 and 62 millimeters.

Sticklebacks were quite numerous in the lake throughout the early summer. In late July a heavy mortality occurred among the larger fish, particularly in the lower (east) part of the lake. Several hundred dead and dying fish were seen on July 22nd.

Judging by the number of rainbow trout taken in gill nets, the lake contains a relatively small population of this species. Some of the small inlet streams also contain rainbows, at least during the summer. These fish are generally small, 6 to 10 inches. The reasons for the lack of larger rainbows in the system are not obvious unless perhaps these fish leave the system at 9 to 10 inches in length and return as steelheads, in which case a larger run of steelheads would be anticipated.

Two series of plankton samples were taken, one in early July and another in late August. We used a one-foot diameter net with No. 20 bolting cloth, making 200-meter tows at the surface and at 5 meters depth at each of three stations (Figure 9). The samples were sent to the Kitoi Bay Research Station for analysis and comparison with samples taken in a similar manner from lakes in the vicinity of the Kitoi Bay Research Station. Table 1 in the Appendix summarizes the plankton data from Afognak Lake.

Table 3. Lengths and weight of emigrant, immigrant, and resident Dolly Varden of the Afognak Lake system, sexes combined. Figures in parentheses are number of fish.

Fork length (cm)	Emigrants May, 1963 Weight (gms)	Immigrants July, 1963 Weight (gms)	Residents June & July 1963 Weight (gms)
12.0 - 13.9			28 (6)
14.0 - 15.9			45 (10)
16.0 - 17.9			56 (24)
18.0 - 19.9		72 (6)	80 (19)
20.0 - 21.9		99 (5)	118 (16)
22.0 - 23.9		129 (14)	137 (27)
24.0 - 25.9		164 (8)	184 (21)
26.0 - 27.9	144 (3)	210 (16)	231 (13)
28.0 - 29.9	182 (4)	254 (26)	300 (8)
20.0 - 31.9	205 (3)	325 (23)	365 (3)
32.0 - 33.9	285 (2)	372 (23)	
34.0 - 35.9	300 (4)	466 (8)	
36.0 - 37.9		497 (5)	
38.0 - 39.9	434 (1)	601 (4)	
40.0 - 41.9		728 (2)	
50.0 - 51.9		784 (2)	

RED SALMON SPAWNING

Red salmon began ascending the two major spawning streams during early July. Ascent was slow and involved relatively few fish. In Hatchery Creek on July 27 we counted 108 jacks and 58 adults; counting in Egg Take Creek was impossible because of turbid water in deep pools in which fish concentrated.

Other counts in Hatchery Creek are given in Table 4. The total size of the run in this tributary is difficult to estimate. Extremely low water during late July and most of August made entrance into the stream and ascent difficult. Light rains for three days starting August 21 increased the flow and triggered the movement of large numbers of spawners. Heavy rains on August 27 through 29, resulting in high and turbid waters, made counting impossible. By the time the waters receded and cleared, few fish remained in the stream.

Because salmon could not ascend Egg Take Creek before the heavy rains of late August, the only spawning which could have occurred was during and after the high-water period. It seems certain therefore that fry production next spring will be far below normal.

During the period September 6 to 15 all of the smaller streams tributary to the lake were examined to determine the amount of salmon spawning. These studies are summarized in Table 3 in the Appendix. It is evident that the contribution of these streams to the salmon production of the system is limited.

Our study was terminated before a proper assessment of beach spawning could be made. We noted, however, concentrations of fish in the lake off the mouths of several of the tributary streams. The largest concentrations occurred on the south shore near the upper end of the lake (see Figure 1, Appendix). Redd construction was also observed here. During August sockeye salmon congregated in considerable numbers off the mouth of Hatchery Creek and redds were constructed in shallow water in the sandy bottom. Spawning was not observed but there is some doubt that eggs deposited here would hatch inasmuch as water movements through the sand would be minimal.

At the end of the spawning season, 19 female sockeye carcasses were examined to determine the number of eggs retained. Of these, 11 fish had discharged all their eggs; the remaining eight contained from 1 to 157 eggs, with an average retention of 44 eggs. The average egg retention of all fish examined is 18 eggs -- less than one percent, assuming an average egg count of 2,500. There is no apparent correlation between size of fish and number of eggs retained.

Magnitude of 1963 Sockeye Run

Two methods of assessing the magnitude of the sockeye run yield quite different results, but these figures probably establish the lower and upper limits of the population size.

An actual count of entering fish was possible only after July 9th when the weir was attended at all times. Prior to this date, six 24-hour counts were made as follows:

Table 4. Enumeration of red salmon in Hatchery and Egg Take Creeks, 1963.

Date	Hatchery Creek Jacks	Adults	Total	Carcasses	Tagged fish[1] No. and date of tagging
8/ 2	326	147	472	18[2]	2 - 6/18; 1 - 7/10
8/ 9			1,155		1 - 6/18 (dead fish) 1 - 7/ 4
8/15			2,275	838[2]	1 - 6/18 1 - 7/ 4 (tag only)
8/24			4,365		3 - 6/11; 5 - 6/18 6 - 6/26; 4 - 7/ 4 2 - 7/10
9/ 9	20	21 f. 25 m.	66	325 f. 290 m. 170 j. 117 unk.	
			Egg Take Creek		
9. 9	38	36 f. 13 m.	87	255 f. 158 m. 332 j. 97 unk.	1 - 7/10; 1 - 7/30

[1] Summary of observations of tagged fish is in Table 2 of Appendix.

[2] Stream bed only; does not include carcasses taken out of the stream by bears.

6/11 - 349	6/12 - 147	6/18 - 246
6/26 - 103	6/27 - 291	6/28 - 140

Assuming these figures represent the average ratio of entry for the period May 25 to July 8, the 95% confidence limits of the estimate for this period are 8,115 and 11,025 fish. To these figures must be added 3,557 the number of fish entering the lake after July 8, making a total estimated spawning population of 11,672 to 14,582 fish.

Applying the Peterson method of population estimation to the data from Hatchery Creek, collected on August 24th (4,365 fish, including 20 of 186 marked), an estimate of 40,600 is obtained.

SPORT FISHING

The amount of sport fishing, its effect on salmon production and its importance in terms of future management programs was considered. Except for some small effort expended in Hatchery Creek and Dry Beaver Valley, all of the sport fishing effort was directed to the outlet stream, and the species sought were the salmon and rainbow trout. All of the fishing was done by military personnel, chiefly from the Kodiak Naval Air Station.

The Navy Recreation Camp normally opens in late May. Prior to that time (3 to 4 weeks) a small crew of men prepares the camp for use during the summer. By the time the camp opens the limited steelhead run is completed and the migrant Dolly Varden have left the system. Sockeyes are entering the river and provide most of the "sport" fishing, although some effort is directed to the small rainbow trout described earlier. The immigrating Dolly Varden are taken only incidentally by the rainbow fishermen and are considered a nuisance species. Fishermen interviewed stated that the Dolly is "wormy" at this time and therefore is not a good food fish. It is believed that less than 100 Dolly Varden were kept and eaten during the entire summer.

Pink salmon enter the river in late July, but are not considered favorably by most fishermen. Some pinks are caught and smoked.

The coho (silver) salmon enter the system in early August and provide excellent fishing; attendance at the camp increases considerably during August. Three steelheads were caught in August, indicating a small fall run of this species.

The estimated catch by sport fishermen during the summer of 1963 is as follows:

Sockeye	1,000 - 1,200
Coho	600
Pink	200
Rainbow	200
Dolly Varden	100
Steelhead	8 - 10

DISCUSSION

This study had the following objectives: 1) to develop information regarding the life histories of the various species of fish in the Afognak Lake system, 2) to determine interrelationships among these species, 3) to determine factors limiting sockeye production and 4) to suggest management procedures for increasing sockeye production.

Regarding the first two objectives, the data presented in this report provide considerable information, at least for the season from May to mid-September. Lacking, however, is a knowledge of the distribution, behavior, and food of young Dolly Varden, and sockeye fry or smolts. The fact that neither of these forms were taken or observed in the areas seined suggests that their distribution elsewhere in the lake may be similar, in which case young Dolly Varden may be highly competitive with small sockeyes for space and food. Predation of coho smolts on young-of-the-year sockeyes, reported in other lakes, was not evident in Afognak Lake during our study. We did not collect the young sockeyes in areas where coho smolts seemed to be concentrated. However, coho smolts may also occur in areas not sampled, areas where age 0 sockeyes concentrate.

We thus have developed no definite knowledge regarding biological factors limiting sockeye salmon production, except that the presence of rather large numbers of coho salmon and Dolly Varden trout must exert a competitive influence even though evidence of summer predation is lacking.

It seems a certainty that the low water levels in the spawning streams reduced the amount of egg deposition in late August, the normal spawning period in this system. The effect of the high water the first week in September is unknown at this time, but should definitely be studied before or during fry emergence next spring. Some redds in Hatchery Creek were undoubtedly scoured out by the rushing water while others may have been covered with silt. In Egg Take Creek, much spawning during the high water levels may have occurred on gravel shoals which will be out of water when levels return to normal. Here again, a study of fry production should evaluate the effectiveness of the 1963 spawning.

The causes and effects of the large increase in the proportion of jacks in the system are now known. The removal of a substantial proportion of large salmon by the commercial fishery can be excluded as a possible cause inasmuch as the commercial fishery was virtually non-existent in 1963 due to a strike in the Kodiak area. The high proportion of jacks may be a temporary phenomenon, but should it remain as high as the 1963 level, or reach higher levels, studies of the progeny of jack matings in this system should be initiated.

The condition of spawning facilities in the two tributary streams may be a factor limiting sockeye production, but the preliminary study in 1961 indicated the composition of the spawning gravel compared favorably with good spawning streams in the area. However, this does not preclude the prior existence of better spawning facilities.

Destruction of salmon by bears and eagles was undoubtedly accentuated in 1963 but the lower water levels, but it seems doubtful that even such predation could account for a substantial decline in annual production.

Some fish also died throughout August without spawning, but these numbers seem insignificant in relation to the total run. These fish, both males and females, seemed to die from exhaustion after struggling through long stretches of shallow water, many of them simply "swimming" up on the shore. Water temperatures as high as 68° F in Hatchery Creek may have contributed to this mortality.

In view of the above discussion, it is apparent that further research needs to be done before management plans can be formulated. This research should have the following objectives: 1) determine the nature and extent of competition between young sockeyes and young Dolly Varden trout and coho salmon; 2) determine the amount of predation of adult Dolly Vardens of young sockeyes in the lake, particularly as the fry enter the lake from the spawning streams; 3) determine the predation on sockeye smolts in Afognak Bay.

If it is determined that Dolly Varden and/or coho salmon provide substantial predation and/or competition, the most effective method of reducing this population would seem to be operating a weir at the lake outlet, preventing these species from entering the lake and allowing use of the entire outlet stream for coho spawning. The cost of such an operation would have to be justified on the basis of economic benefits derived from an increased sockeye run. Removal of migrant Dolly Varden and coho salmon from the lake might, however, result in an increased population of resident Dolly Varden which would offset some or all of the advantage gained by reduction of migrant Dolly Varden and coho salmon.

APPENDIX

Table 1. Afognak Lake 1963 plankton samples (calculated numbers per cubic meter).

Date	Station and Depth	Settled Volume (ml)	Adult Daphnia	Bosmina / Bosmina Eggs	Copepods / Nauplii	Large Rotifers (Kellicottia, Asplanchna, etc.)	Small Rotifers (Keratella, etc.)	Tabellaria Chains	Colonial Anabena	Dinobrian	Ceratium	Pollen
7/5	1--0m.	6	0	590-0	65-327	2550	1634	4120	524	0	720	5550
7/5	1--5m.	5.5	63	1328-0	188-443	1263	4620	2020	0	0	190	885
7/5	2--0m.	5.5	248	1556-0	188-188	810	1680	810	0	0	560	560
7/5	2--5m.	6	0	1007-0	309-464	4875	3950	3718	77	0	620	696
7/23	3--0m.	1	0	622-0	124-0	0	994	559	0	0	1241	0
7/23	3--7m.	3	0	602-452	1128-376	301	827	0	75	0	2258	0
8/26	3--0m.	4.5	0	3438-1100	481-137	412	15,180	618	343	0	3434	687
8/26	3--5m.	3.5	0	2322-906	396-117	227	13,660	454	117	0	1475	0
8/26	2--0m.	1.5	0	950-658	365-0	73	1,570	585	0	0	1242	0
8/26	2--5m.	4	0	1913-1064	425-71	213	29,250	1843	0	0	2760	71
8/26	1--0m.	3	0	1537-51	51-51	51	462	154	0	0	717	0
8/26	1--5m.	4	0	963-412	183-46	229	582	1238	0	0	2520	0

Table 2. Summary of observation on distribution of tagged fish.

Date of Observation	Location	Date(s) of Tagging	Number of Tags	Remarks
7/5	Mouth of Hatchery Creek	6/26	1	
7/24	Lower Hatchery Creek	7/10	1	
7/25	Lower Hatchery Creek	7/4	1	
		7/10	1	
7/25	Lake, off E. T. Creek	7/4	1	No tags in E. T. Creek
		7/10	1	
7/31	Mouth Hatchery Creek	7/10	1	On dead jack
8/2	Lower Hatchery Creek	6/18	2	
		7/10	1	
8/9	Upper Hatchery Creek	6/18	1	Dead ♂
	Midway Hatchery Creek	7/4	1	
	Egg Take	6/18	1	
8/11	Lower Hatchery Creek	7/10	1	Loose tag on bottom
8/12	Lake Sta. 3	7/10	1	In eagle nest
8/15	Upper Hatchery Creek	7/4	1	On carcass
	Mouth Hatchery Creek	6/18	1	
8/20	Mid Hatchery Creek	6/26	1	
	Upper Hatchery Creek	6/18	1	
8/22	Lower Hatchery Creek	6/18	4	
		7/4	1	
		7/10	1	
	Lower Egg Take	7/4	2	
		8/7	1	
	Lakeshore, Trib 4	6/18	1	
	In Trib 4	6/26	1	
9/6-15	Trib 4	7/30	1	
	Egg Take Creek	7/10	1	
		7/30	1	
	Trib 6	7/30	1	
	Lake, off Trib 7	7/10	1	May have been g/w 8/7*
		7/24	3	
		7/30	3	

*We found that it was difficult at a distance to distinguish between the green streamer and the green and white combination.

Table 3. Summary of observations of salmon in tributary streams, September 6 - 15.

Stream	Number of Salmon in Streams: Sockeye Alive	Sockeye Dead	Coho Alive	Coho Dead	Pink Alive	Pink Dead	Remarks
1	0	0	0	0	3	2	A few sockeyes observed in late August
2	1	1	0	0	1	1	10-15 coho near mouth of stream
3	1	8	1	2	0	0	50 coho near mouth
4	7	27	0	0	0	0	1 sockeye tagged 7/30
5 (Egg Take)	87	842	See remarks		2	0	Many coho, no estimate, 1 sockeye tagged 7/10 1 sockeye tagged 7/30
6	1	32	0	0	0	0	Sockeye and coho in mouth of stream - 1 tagged 7/30
7	0	1	0	0	0	0	300 sockeye in lake near mouth
8	0	0	0	0	0	0	2 sockeye and many coho at mouth
9	1	88	0	0	0	0	
10	3	0	0	0	0	0	
11	0	0	0	0	0	1	
12	0	6	0	0	0	0	
13 H. Creek	66	902	1	0	64	7	